REINWARDTIA
Vol 12, Part 5, pp: 391 – 404

FLORISTIC COMPOSITION AND STRUCTURE OF SUBALPINE SUMMIT HABITATS ON MT. GEDE-PANGRANGO COMPLEX, CIBODAS BIOSPHERE RESERVE, WEST JAVA, INDONESIA

Received December 1, 2008; accepted December 3, 2008

A. SADILI
Herbarium Bogoriense, Botany Division, Research Center for Biology – LIPI, Jl. Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia

K. KARTAWINATA
Herbarium Bogoriense, Botany Division, Research Center for Biology – LIPI, Jl. Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia; UNESCO, Jakarta Office, Jakarta, Indonesia. E-mail: kkjak@indo.net.id (author for correspondence)

A. KARTONEGORO
Herbarium Bogoriense, Botany Division, Research Center for Biology – LIPI, Jl. Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia

H. SOEDJITO
Herbarium Bogoriense, Botany Division, Research Center for Biology – LIPI, Jl. Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia; Indonesian National MAB Committee, LIPI, Jakarta, Indonesia

A. SUMADIJAYA
Herbarium Bogoriense, Botany Division, Research Center for Biology – LIPI, Jl. Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia

ABSTRACT

SADILI, A., KARTAWINATA, K., KARTONEGORO, A., SOEDJITO, H. & SUMADIJAYA, A. 2009. Structure and composition of subalpine summit habitats on Mt. Gede-Pangrango complex, Cibodas Biosphere Reserve, West Java, Indonesia. *Reinwardtia* 12 (5): 391–404. — We undertook a phytosociological analysis of the subalpine herbaceous and shrubby vegetation at the Mandalawangi and Suryakencana meadows and the scrub at the Crater Side at the tops of Mt. Gede and Mt. Pangrango in the Cibodas Biosphere Reserve. We recorded 30 species of 18 families of saplings, shrubs, seedlings and herbs in 78 quadrats with a total area of 7,800 m^2. *Anaphalis javanica*, a woody tall herb and long-lived pioneer was the dominant species in the sapling and shrub stratum, while *Isachne pangerangensis, Tripogon exiguus* and *Carex verticillata* were prevalent in the seedling and herb stratum at Mandalawangi and Suryakencana. Stunted shrub is *Vaccinium varingaeifolium,* dominant in the Crater Side scrub. Based on the importance values, the Mandalawangi meadow may be designated as the *Anaphalis javanica-Isachne pangerangensis* community type, the Suryakencana meadow as *Anaphalis javanica-Tripogon exiguus* community type and the Crater Side scrub as *Vaccinium varingiaefolium-Seliguea feei* community type. The similarity indices between Mandalawangi and Suryakencana community types were very high (>75 %) while those between the Crater Side and Mandalawangi and the Crater Side and Suryakencana were very low (<10 %). Poor soil conditions and fire seem responsible for the perpetual existence of *A. javanica*.

Keywords: Structure and composition, subalpine meadows, *Anaphalis javanica*, top of Mt Gede-Pangrango

ABSTRAK

SADILI, A., KARTAWINATA, K., KARTONEGORO, A., SOEDJITO, H. & SUMADIJAYA, A. 2009. Struktur dan komposisi habitat subalpin di puncak G. Gede-Pangrango, Cagar Biosfer Cibodas, Jawa Barat, Indonesia. *Reinwardtia* 12 (5): 391–404. — Analisis fitososiologi telah dilakukan pada vegetasi terna di alun-alun Mandalawangi dan Suryakencana dan semak di Tepi Kawah daerah puncak G. Gede dan G. Pangrango di Cagar Biosfer Cibodas. Tercatat sebanyak 30 spesies dari 18 suku belta, perdu, semai, dan terna dalam 78 petak cuplikan dengan luas total 7.800 m^2. *Anaphalis javanica*, terna tinggi mengayu dan pionir berumur panjang, adalah spesies dominan pada stratum belta dan perdu , sedangkan *Isachne pangerangensis, Tripogon exiguus* dan *Carex verticillata* adalah jenis utama pada stratum semai dan terna di alun-alun Mandalawangi dan Suryakencana. Perdu kerdil *Vaccinium varingaeifolium* adalah jenis dominan dalam komunitas semak Tepi Kawah. Berdasarkan nilai pentingnya vegetasi di alun-alun Mandalawangi dapat disebut sebagai tipe komunitas *Anaphalis javanica-Isachne pangerangensis*, di alun-alun Suryakencana tipe komunitas *Anaphalis javanica-Tripogon exiguous* dan semak Tepi Kawah tipe komunitas *Vaccinium varingiaefolium-Seliguea feei.* Indeks kesamaan antara tipe komunitas di

Mandalawangi dan di Suryakencana sangat tinggi (>75 %), sementara antara tipe komunitas Tepi Kawah dan Mandalawangi serta antara tipe komunitas Tepi Kawah dan Suryakencana sangat rendah (<10 %). Kondisi tanah miskin dan juga kebakaran tampaknya merupakan faktor yang mempertahankan kelanggengan *A. Javanica*.

Kata kunci: Struktur dan komposisi, alun subalpin, *Anaphalis javanica*, puncak G. Gede-Pangrango

INTRODUCTION

The Cibodas Biosphere Reserve comprises natural ecosystems contained within the Gunung Gede-Pangrango National Park and man-made ecosystems surrounding the Park bordered by the encircling highway connecting Ciawi-Sukabumi-Cianjur-Puncak-Ciawi (Figure 1). The Cibodas Biosphere Reserve is listed as a member of the World Network of Biosphere Reserves (Rustiami, 2004). It is an important conservation and biological research site that has a long history in Indonesia.

The natural ecosystems within the Park have a high plant species richness, where to date 823 species of flowering plants have been recorded (Sunarno & Rugayah, 1992) and the number have increased with additions from recent inventory and ecological studies. The site has attracted a large number of scientists to explore and study the tropical biology and ecology of plants and animals in these ecosystems since the establishment of the Botanic Gardens in Bogor in 1817. The brief history of scientific research in the area is included in the Mountain Flora of Java by Van Steenis *et al.* (1972, 2006), while earlier Van Steenis & Van Steenis-Kruseman (1953) listed botanists and their publications based on research in Mt. Gede-Pangrango up to 1952. All of them were the results of qualitative observations. Some of the noted earlier botanists and plant ecologists were Blume (1825), Docters van Leeuwen (1933), Junghuhn (1845), Hasskarl (1840), Koorders (1918–1923), Korthals (1848), Kramer (1926, 1933), Reinwardt (1819), Seifriz, (1923), Teysmann (1842), and Went (1940). After the 2nd World War research in the area has been undertaken by Abdulhadi *et al.* (1998), Meijer (1959), UNESCO *et al.* (1975), Srijanto (1987), Sunarno & Rugayah (1992), Yamada, (1975, 1976, 1977), and several undergraduate and graduate students from various universities.

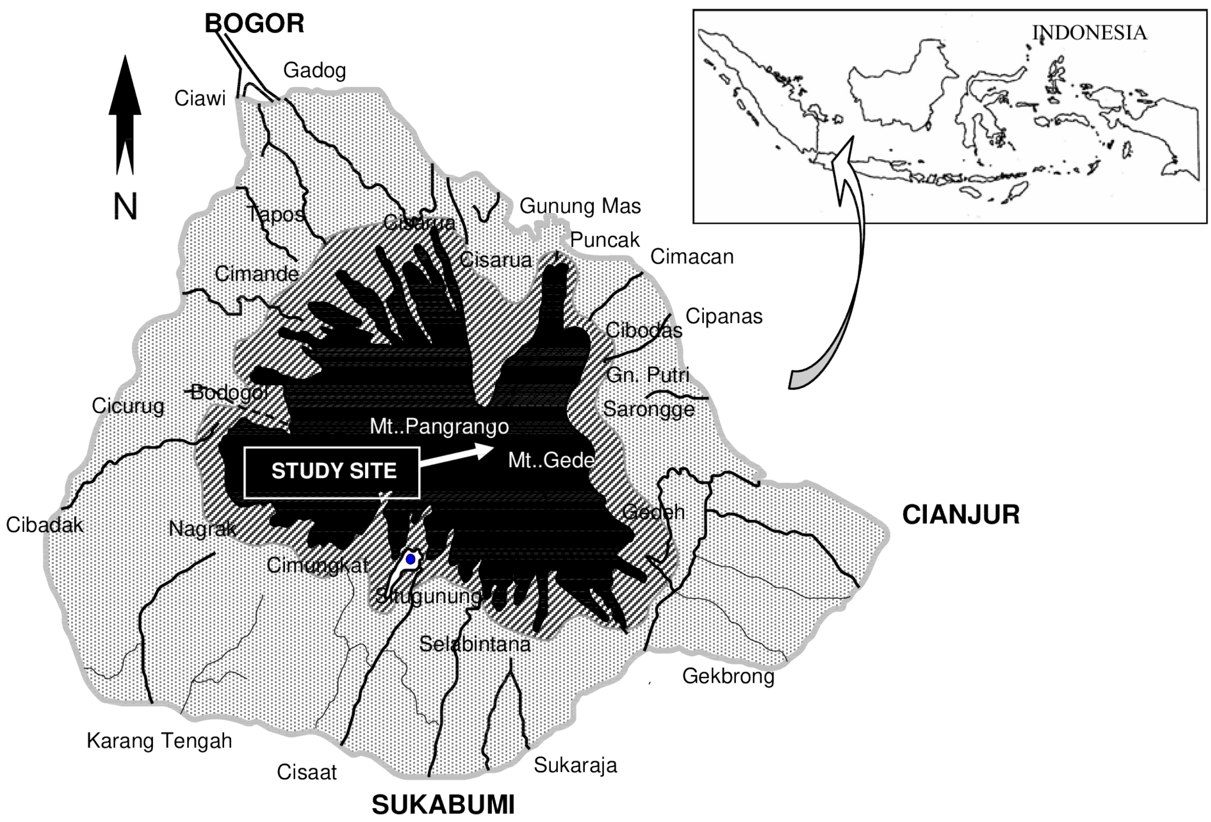
Quantitative ecological studies in the natural ecosystems of the Cibodas Biosphere Reserve have been concentrated on the montane and subalpine forests (Abdulhadi *et al.,* 1998; Srijanto, 1987; UNESCO *et al*., 1975; Yamada, 1975, 1976, 1977); and none has been conducted on subalpine herbaceous and shrubby communities. The following account reports the results of a quantitative phytosociological study in the *alun-alun* (open herbaceous and shrubby meadows) Mandalawangi and Suryakencana and the crater side scrub at the tops of Mt. Gede and Mt. Pangrango, complementing the qualitative records of vegetation made earlier by various botanists, particularly Docters Van Leeuwen (1933) and Van Steenis *et al.* (1972, 2006).

STUDY SITE

The Cibodas Biosphere Reserve comprises natural ecosystems contained within the Gunung Gede–Pangrango National Park (GGPNP) and man-made ecosystems surrounding the Park, bordered by the intercity highway connecting Ciawi-Sukabumi-Cianjur–Puncak–Ciawi, with the total area of 108,000 hectares. It is located within Bogor, Cianjur and Sukabumi Districts, West Java (Figure 1). The GGPNP comprises an area of 21,975 hectares and was established initially in 1980 through the Decrees of the Minister of Agriculture in 1980 and was extended in 2003 through the Decree of Minister of Forestry in 2003 (Balai TNGGP, 2007). The park area starts at an elevation of 700 m (Helmi *et al.,* in preparation) and extends upwards to the areas of twin mountains, Mt. Gede (2,962 m alt.) and Mt Pangrango (3,019 m alt.), connected by a sadle at 2,400 m alt. at Kandang Badak. It covers upper lowland forests, montane forests, subalpine forests, subalpine scrubs, subalpine grasslands, subalpine herbaceous communities and subalpine swamps (for detailed descriptions see Docters Van Leeuwen, 1933; Van Steenis *et al*., 1972, 2006 a & b; Yamada, 1975, 1976, 1977). On the tops of Mt. Gede-Pangrango, the subalpine vegetation dominates the landscape and consists of open herbaceous and shrubby meadows locally known as the *alun-alun* dominated by *Anaphalis javanica,* scrubs dominated by *Vaccinium varingiaefolium* and low forests dominated by *Leptospermum flavescens* or *Albizia lophanta.*

The climate diagram (Figure 1) shows the mean monthly rainfalls and temperature at the top of Mount Pangrango. The mean annual rainfall at the top of Pangrango is 3369 m and at Kandang Badak is 3818 mm (LMG, 1969). In the Schmidt & Ferguson (1951) scheme, the rainfall in the

CIBODAS BIOSPHERE RESERVE (108.000 Ha.):


BOGOR
N
Ciawi
Gadog
INDONESIA
Tapos
Cisarua
Gunung Mas
Puncak
Cisarua
Cimacan
Cimande
Cibodas
Cipanas
Gn. Putri
Cicurug
Bodogol
Sarongge
Mt..Pangrango
STUDY SITE
Mt..Gede
CIANJUR
Cibadak
Nagrak
Gedeh
Cimungkat
Situgunung
Selabintana
Gekbrong
Karang Tengah
Cisaat
Sukaraja
SUKABUMI

■ Core zone (15,196 Ha.): Conservation area covering montane forest, subalpine forest, and subalpine scrub and herbaceous vegetation.

▨ Buffer zone (12,700 Ha) : It comprises Cibodas Botanical Garden, Safari Garden, tea plantation, and planted forests.

░ Transition zone (80,104 Ha): Development area comprising, rice fields, home gardens, dry land crop gardens, settlements, industries, recreation areas, etc.

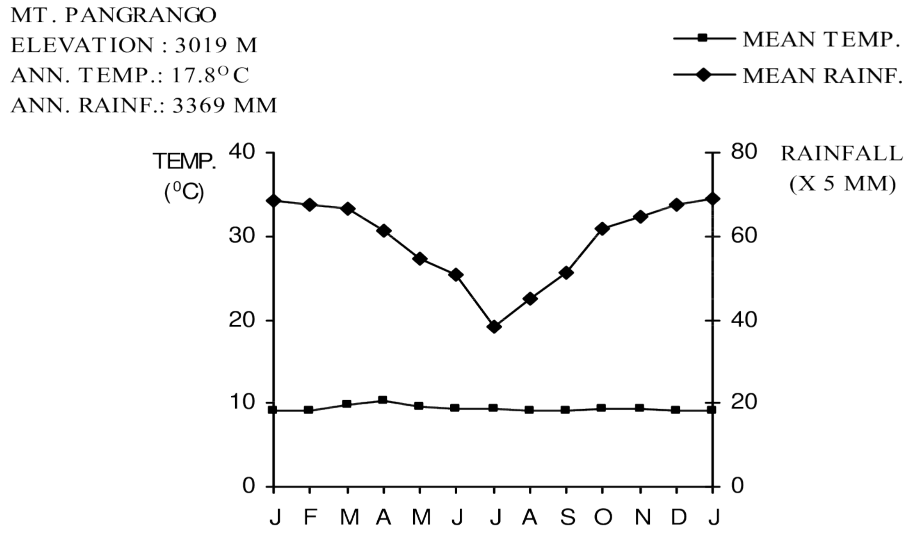


Figure 1. The Cibodas Biosphere Reserve bordered by the intercity highway connecting Ciawi, Cianjur and Sukabumi (Redrawn after TNGP cited by Rustiami, 2004). The climate diagram shows the mean monthly rainfall and temperature at the top of Mount Pangrango (3019 m alt.) (Data from LMG 1969 & Docters Van Leeuwen, 1933).

entire park, including the area of the tops of Mt. Gede–Pangrango, belongs to the Type A, which is very wet. The rainfall is not uniformly distributed throughout the year, but there is a 2 month dry period in July and August, with the mean monthly rainfall of 80 and 85 mm, respectively. Data on the mean number of rain days shows that the dry season has little effects; during the driest month in July and August, where the number of rain days was 16.4 and 14.7, respectively (LMG, 1969) implying that rain falls every two days with a significant measurable amount. The monthly mean of daily air temperature at the top of Pangrango ranges from 8.4°C to 9.7°C with the annual mean of 9.0°C, the highest mean daily temperature varies from 11.3°C to 11.9°C between 10 AM. and 2 PM. (Docters Van Leeuwen, 1933). In the Gede–Pangrango mountain top area, in addition to rainfall, precipitation from the fog that develops almost every day and forms dew on leaves and mosses in the forest is significant also, but to date no data are available (Van Steenis *et al.,* 1972, 2006)

The soils in the top area consist mainly of stones and gravels deriving from lava and volcanic ash which may be designated as grey regosols and lithosols, while on the forested slopes all belong to the mixture of andosol and latosol or latosol and regosol (FAO, 1978)

The study sites were located in the *Alun-alun* Mandalawangi and *Alun-alun* Suryakencana and a site of open low woody vegetation near the crater of Mt. Gede, which for short will be called Mandalawangi, Suryakencana and the Crater Side, respectively. Herbaceous vegetation covers the *alun-alun* and always looks dry, especially grasses and *Anaphalis javanica.* The *alun-aluns* are surrounded by subalpine forests, dominated jointly by *Vaccinium varingiaefolium* and *Leptospermum flavescens* or in places by *Albizia lophanta.* Hikers have frequently visited the sites and in places left disturbances, although as a whole the areas are still in natural state. The severe disturbance was attributed to fire, which apparently has frequently occurred in the surrounding forests. Docters Van Leeuwen (1933) reported fire occurred on the western side of Mt. Gede and in the present observation it affected the forests on the northern side of a smaller mountain, Mt. Gumuruh. In 2006, fire spread from an abandoned campfire and burnt part of the *Anaphalis javanica* stand in the western section of Suryakencana.

The *Alun-alun* Mandalawangi (Figure 7) is located at 2,978 m alt. at 06° 46.403‘ E and 106° 58.042’ S, about 100 m north-east from the top of Mt Pangrango at 06° 46.225’ E and 106° 57.913’ S. The *alun-alun* is a meadow located on a basin derived from the inactive crater and now forms an open and roundish field with diameter of about 250 m, making a total area of about five hectare. The central section of the field is somewhat flat, consisting of sand and gravel, while the outer section towards the edge is sloping and covered by *A. javanica*, where the soil layer is of 3–5 cm thick. In the middle, a small river is running from East to West. The field is surrounded by forest, loaded with *Usnea* sp. and other mosses, with soil of about 10 cm thick. During the study on August 2007, the weather was dry with temperature measurements averaging 4°C at 6 AM., 18°C at Noon, and 12°C at 9 PM. Fog descended every day between 4 and 8 PM.

The *Alun-alun* Suryakencana (Figure 8) is a sickle-shaped meadow, developed from the extinct volcanic crater of about 2 km long and about 200 m wide, stretching from north-east to south-west, making up a total area of 49.72 hectares. It is located about 200 m below the top of Mt. Gede on the narrow gap separating Mt. Gede on the north side and smaller mountain Mt. Gumuruh on the south side at 06° 46.200’ E and 106° 57.821’ S at an altitude of 2,719 m. On the west side the land is sloping toward the center where a relatively big stream is running, with smaller streams coming from the gentle slopes around it. During the rainy season the river is overflowing (Van Steenis *et al.,* 1972, 2006), but during the dry season such as during the present study the river is dry. On the east side the slope is more gentle, especially from the middle section toward the eastern edge of the field. The soil in the central section of the field is yellow, thin and mixed with sand and gravel, while at the edge next to the forest the dark yellow soil is about 5–10 cm thick, mixed with gravels and small boulders or tallus, where stunted *A, javanica* grows and the entire soil surface in between *A, javanica* is covered by lichen *Stereocaulon graminosum* and mosses, especially *Rhacomitrium lanuginosum.* The air temperature measured during the study was 5°C (at 6 AM.), 22°C (at Noon) and 2°C (at 9 PM.).

The Crater Side (Figure 9) is an area of about two hectares, which is located at 2,514 m altitude near two craters (Kawah Lanang and Kawah Wadon), at 06° 468.68’ E and 106° 58.863’ S. The site is sloping towards the east, ending at the edge of a very steep ravine, and the slope varies up to 40%. The substrate mainly consists of boulders of varying sizes up to 2 m in diameter. The vegetation is a sparse scrub, composed mainly of dwarf trees of *Vaccinium varingiaefolium, Albizia lophanta* and *Leptospermum flavescens*, as well as tall herb *Anaphalis javanica,* growing between boulders. The area is very dry where beard-moss *Usnea* and other species of mosses can hardly grow.

METHOD

The quadrat method was used to sample the Mandalawangi and Suryakencana meadows and the scrub on the Crater Side. Since there were no trees, the vegetation was stratified into two strata only: (1) Sapling and shrub stratum, where a sapling or shrub is defined as a woody plant with DBH (Diameter at Breast Height) ≤10 cm with height of ≥ 50 cm; tall herb is included here also, and (2) Seedling and herb stratum, where a seedling or a herb is defined as a plant with height of ≤50 cm. Twenty three (10 x 10 m) quadrats with the total area of 2,300 m^2 were established and distributed systematically with intervals of 20 m in Mandalawangi, 50 quadrats with the total areas of 5,000 m^2 in Suryakencana, and five quadrats with a total area of 500 m^2 in the Crater Side. Each quadrat was divided into four (5 x 5 m) plots for recording saplings and shrubs and a 1 x 1 m subplot for seedlings and herbs, which was nested within one of the four plots within each quadrat. Different life forms were identified to the species level, their heights were measured and the percentage of cover of each species was estimated. The number of individuals of each species within the quadrats, plots and subplots were counted. Additional information on soil and substrate as well as other habitat conditions for each quadrat were noted and flowering status of species were recorded. Data were analyzed using the vegetation parameters of dominance (as expressed by the percentage of cover), density and frequency of each species, whose relative values were summed up and presented as the Importance Values, expressed in percentages (Mueller–Dombois & Ellenberg, 1974). Voucher specimens were collected and identified at the Herbarium Bogoriense in Cibinong. The species nomenclature follows Flora of Cibodas (Sunarno & Rugayah, 1992) and Flora of Java (Backer & Bakhuizen van den Brink Jr., 1963-1968).

RESULTS AND DISCUSSION

A total of 30 species of 18 families of saplings, shrubs, seedlings and herbs were recorded in 78 quadrats in the study sites. In the sapling and shrub stratum only 18 species were recorded in the vegetation sampled in Mandalawangi (13 spp.), Suryakencana (14 spp.) and the Crater Side (10 spp.).

Of the total of 18 species of saplings, shrubs, and woody herbs, seven species were common to the three sites, four species in Mandalawangi and Suryakencana, and one species in Suryakencana and the Crater Side, while species with restricted distribution were only two in Mandalawangi, Suryakencana and the Crater Side, respectively (Annex 1).

In the sapling, shrub and woody herb stratum, the Shannon diversity indices of sapling, shrub and woody herb communities in the three sites are low, *i.e.* 1.69 for Mandalawangi, 1.67 for Suryakencana and 1.16 for the Crater Side. The species area curve (Figure 3) shows that the number of species increases rapidly up to 1,500 m^2 and from this point onwards the increase is slight, confirming further the low species diversity. It may be implied also that the minimum area for this sapling community is 1,500 m^2.

In this stratum, it can be noted further that *Anaphalis javanica* was dominant, as indicated by its high importance value and relative dominance in Mandalawangi and Suryakencana, but its presence in the Crater Side was insignificant. (Figure 2, Annex 1) The next important species were *Vaccinium varingiaefolium, Rhododendron retusum* and *Gaultheria punctata*, which were dominant and co-dominant species in the Crater Side. They were less significant in Mandalawangi and Suryakencana, and even *Rhododendron retusum* was absent. *Albizia lophantha* and *Leptospermum flavescens* were the prominent tree species in these sites, but they were mostly crooked and low in stature, hence constituted only the component of the sapling and shrub stratum. They grew well at the edges of the *alun-alun,* merging with surrounding forests dominated by *L. flavescens,* which could reach the height of more than three meters. This is apparently the poorly developed variant of the subalpine forest occurring in the summit area described quantitatively by Yamada (1977) and earlier qualitatively by Docters Van Leeuwen (1933) and Van Steenis *et al.* (1972, 2006), where *A. lophanta, L. flavescens* and *V. varingiaefolium* were the leading species.

A. javanica was widespread throughout, but formed dense stands at the edge of Mandalawangi and Suryakencana. In contrast, it did not develop well and was sparsely distributed in the Crater Side, where it grew only on firm and hard soils between boulders. Outside the quadrats it could be found also growing in the valleys of dead and active craters as well as on poor, sandy and stony soils. *A. javanica* groves developed densely on the slope and formed a tall scrub with height up to 1.5 m. The soils were covered by mosses with various herbaceous species growing in between. Quantitatively there was no consistent correlation between percentage of cover and habitat (slope, soil depth and soil pH), but qualitatively it could be observed that *A. javanica* grew in roups on open and flat lands or gentle slopes with poor sandy or stony soils as well as volcanic rocks. Our observations confirm the earlier work by Docters Van Leeuwen (1933) and Van Steenis *et al.* (1972, 2006), who noted also that from time to time *A. javanica* groves died because of frosts that took place quite frequently at night. Docters Van Leeuwen (1933) noted that various aspects of *alun-alun* had not changed since they were described by Junghuhn (1845) and later by Korthals (1848). *A. javanica* occurred also in the *alun-alun* at the top of Mt. Papandayan, West Java (Van Steenis, 1932), and less abundantly at Mt. Ceremai, West Java (Lam, 1925), Mt. Sumbing and Mt. Sindoro in Central Java (Docters Van Leeuwen, 1930).

The occurrence of apple trees, *Malus domestica,* in Mandalawangi and Suryakencana is interesting. They were the survivor of a variety of temperate fruit and vegetable species planted in an experimental garden at Kandangbadak by Teysmann in 1839, to cater the need of the Governor General for European vegetables and fruits (Van Steenis *et al,*. 1972, 2006).

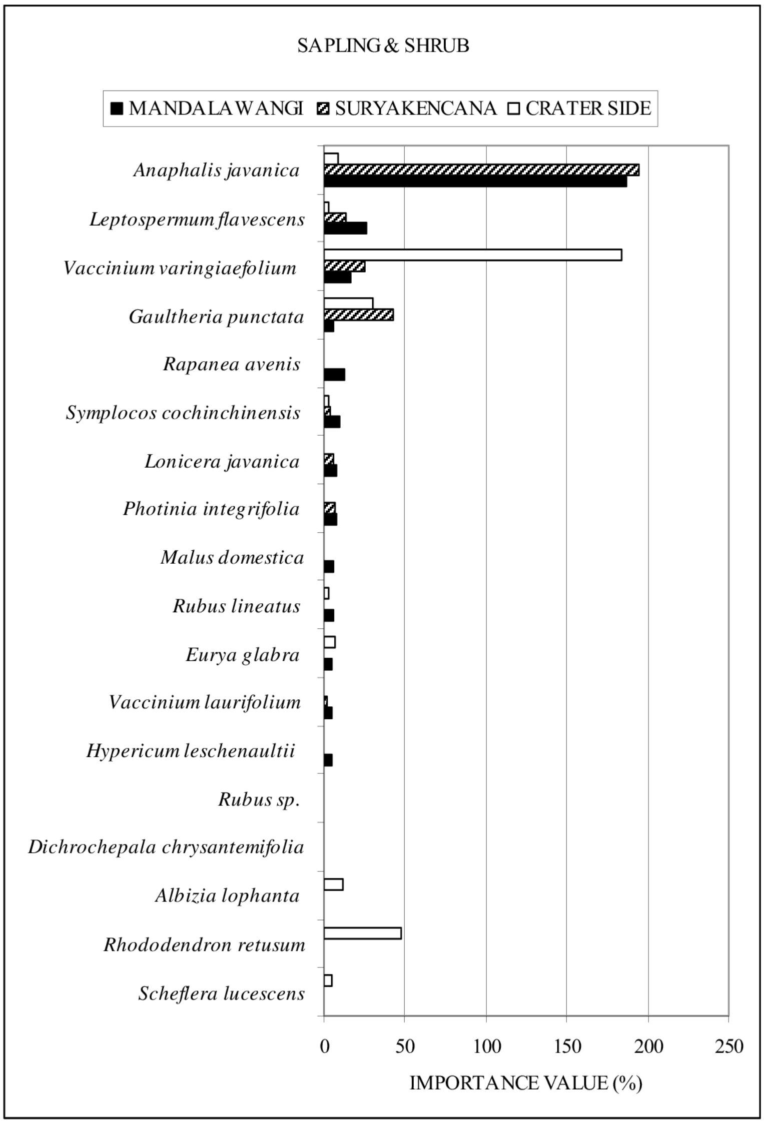


Figure 2. Importance Values of saplings and shrubs at Mandalawangi, Suryakencana and Crater Side on the tops of Mt. Gede and Mt. Pangrango, Cibodas Biosphere Reserve.

In the seedling and herb stratum altogether 21 species were recorded, of which 11 species occurred in Mandalawangi, 16 species in Suryakencana and five species in the Crater Side (Figure 4, Annex 2). The Shannon diversity indices for the three communities in this stratum are also low, *i.e.*, 1.82 for Mandalawangi, 2.17 for Suryakencana and 0.56 for the Crater Side. The species-area curve (Figure 5) shows that the number of species of seedlings and herbs increases rapidly up to 20 m^2 and from this point onwards the increase is slight, confirming further the low species diversity. It suggests that the minimum area for this seedling and herb community is 20 m^2.

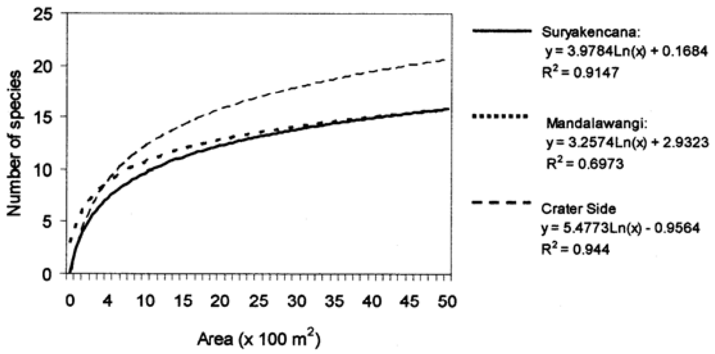


Figure 3. Species-area curves of saplings, shrubs and woody herbs at Mandalawangi, Suryakencana and Crater Side on the tops Mt. Gede and Mt Pangrango, Cibodas Biosphere Reserve.

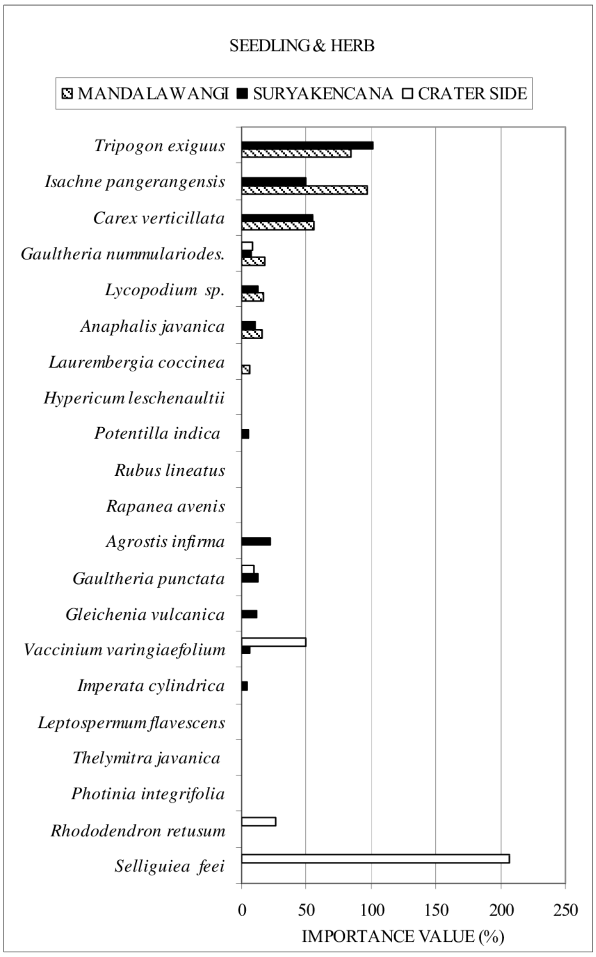


Figure 4. Importance Values of herbs and seedlings at Mandalawangi, Suryakencana and Crater Side.

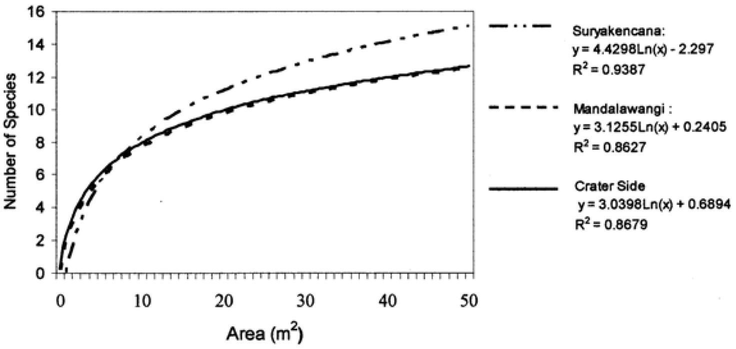


Figure. 5. Species-area curves of seedlings and herbs at Mandalawangi, Suryakencana and the Crater Side on the tops Mt. Gede and Mt. Pangrango, Cibodas Biosphere Reserve.

It can be noted from Annex 2 that only one species, *Gaultheria nummularioides*, occurred throughout the three sites, six species in Mandalawangi and Suryakencana and three species in Suryakencana and the Crater Side, while species with restricted distribution were four only in Mandalawangi, six only in Suryakencana and two only in the Crater Side. Note that in Mandalawangi and Suryakencana, two species of Poaceae (*Isachne pangerangensis* and *Tripogon exiguus*) and Cyperaceae (*Carex verticillata*) were prevalent in this stratum, while in the Crater Side a species of fern, *Selliguiea feei*, was dominant (Figure 4). The association of *Isachne pangerangensis* and *Tripogon exiguous* is positively correlated in Mandalawangi (r = 0.597) but the correlation is negative in Suryakencana (r = – 0.610), which might be attributed to different habitat conditions.

Outside the plots we recorded five additional grass species (*Agrostis infirma, Deyeuxia australis, Vulpia bromoides, Isachne globosa* and *Poa annua*). Van Steenis *et al.* (1972, 2006), however, recorded only five species in the Mt,. Gede-Pangrango area. *Vulpia bromoides* is a new record as previously it did not occur in this area (Sumadijaya & Veldkamp, 2009; Sunarno & Rugayah, 1992; Van Steenis *et al.*, 1972, 2006).

In Mandalawangi, toward the edge, the community was richer, where grasses *Agrostis infirma* and *Deyeuxia australis* formed small patches together with big bunches of sedges. On the southwest side the middle part was covered by a thick carpet of *Isachne pangerangensis* and under this carpet water was dripping. On the eastern side water was oozing from the soil and during the rainy season it became swampy where grasses and sedges were prevalent and very frequently the moss *Sphagnum* was dominant and constituted the main contributor in the peat formation (Van Steenis *et al.,* 1972, 2006).

As indicated in the method above the communities can be stratified only into two strata, *i.e.* sapling and shrub stratum and seedling and herb stratum. Beside the stratification, density is the only vegetation parameter that can be best used to indicate the structure of the community. Table 1 shows the density of plants in two strata. In the first stratum the highest densities occurred in the Crater Side, consisting of woody species *A. lophanta, G. punctata, L. flavescens* and *V. varingiaefolium* and the densities of these species were low in the seedling and herb layer, where the fern *Selliguiea feei* was prevalent (Figure 4, Annex 2). The average height of *A. javanica* was 109 cm in Mandalawangi and 77 cm in Suryakencana. In the Crater Side, however, it reached up to 143 cm, growing well singly and scattered in fine substrates between volcanic rubbles and boulders, apparently experiencing no competttion from other plants.

Seedlings of *A. javanica* had low density, dominance and importance values in both Mandalawangi and Suryakencana, occupying the 6th rank and 8th rank, respectively (Annex 2). We recorded that the seedling density was 1,304/ha in Mandalawangi, and 15,800/ha in Suryakencana (Table 1). It is implied that *A. javanica* was hardly regenerating under its own shade indicating the pioneer status of the species. Van Steenis *et al.* (1972, 2006) noted that *A. javanica* seedlings grew very slowly on volcanic ash deposits and other substrates around craters. The species was said to be a long-live pioneer and was also capable to invade burned subalpine forests, but later disappeared as the burned forest recovered. This has been shown by the dense lower subalpine forest. On the western slope of the Mt. Gumuruh that was burned in 1914; the burned forest was later invaded by *A. javanica* and slowly reverting to a dense forest (Docters Van Leeuwen, 1933). Van Steenis *et al.* (1972, 2006) stated that the slow growth of *A. javanica* was attributed to poor soil conditions and apparently the weathering and soil formation from volcanic materials were progressing very slowly, while at the same time high rainfall and high porosity of the materials facilitated leaching. Such situations were not favorable for forest regeneration but allowing the growth of *A. javanica,* which did not require good soils to grow.

Fire apparently has been recurrent in the *alun-alun* and more frequently in recent years in view of the frequent visits of hikers, who camped out conveniently there and often negligently left the campfire burning when they left. Fire seems to be a factor, along with poor soil conditions, that maintain the existence of the *A. javanica* dominated community in the *alun-alun*. There is a slight indication of tree species aggressively invading the community. This is indicated by low relative density of saplings and seedlings of the tree species in the community such as *Albizia lophanta, Leptospermum flavescens, Rapanea avenis, Symplocos cochinchinensis, and Vaccinium varingiaefolium* (Annexes 1 & 2).

Tabel 1. Density (individuals/hectare) of saplings, shrubs, seedlings and herbs within two strata of the communities at Mandalawangi and Suryakencana, where *A. javanica* was the dominant species in the sapling and shrub stratum.

Stratum	Life form and species	Density (Individuals/ha)		
		Mandalawangi	Suryakencana	Crater Side
1	Sapling and shrub:			
	(a) all species	2,461	2,960	5,060
	(b) *A. javanica*	1,596	1,976	400
2	Seedling and herb:			
	(a) All species	2,830,435	2,721,780	776,000
	(b) *A. javanica*	1,304	15,800	0

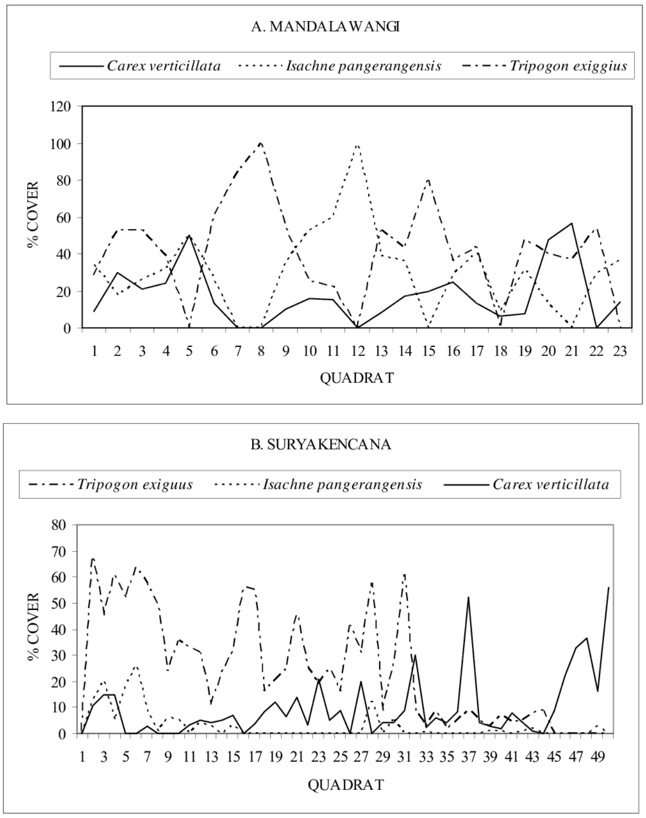


Figure 6. Percentage of cover of *Carex verticillata, Isachne pangerangensis* and *Tripogon exiguus* in quadrats at Mandalawangi (A) and Suryakencana (B).

Based on the Importance Values of sapling-shrub stratum and those on seedling-herb stratum, the Mandalawangi meadow may be designated as the *Anaphalis javanica-Isachne pangerangensis* community type (Figure 7), the Suryakencana meadow as *Anaphalis javanica-Tripogon exiguus* community type (Figure 8) and the Crater Side scrub as *Vaccinium varingiaefolium-Seliguea feei* community type (Figure 9) Using Jaccard's formula (Mueller-Dombois & Ellenberg, 1974) and the Importance Values, the Index of Similarity (IS) of community types at Mandalawangi and Surayakencana was 95.82% for the sapling stratum and 75.23% for seedling stratum, respectively. The similarities between the Crater Side community type and the community types at Mandalawangi and Suryakencana at the sapling stratum are high, with IS of 69.60% and 78.93%, respectively, while at the seedling stratum was very low, with IS of 2.11% and 9.72%, respectively. These community types are similar to those at the *alun-alun* in Mt. Papandayan (Van Steenis, 1930, 1932), and Mt. Ceremai (Lam, 1925), West Java and Mt. Sumbing and Mt. Sindoro (Docters van Leeuwen, 1932) Central Java, although *A. javanica* occurred less abundantly. Floristically at generic level and structurally these community types are comparable to those in the subalpine regions in various mountains in Indonesia, such as in Papua (Hope, 1976; Johns *et al.,* 2007), while community type dominated by *Vaccinium varingiaefolium* is common as pioneer vegetation in the volcanic mountains elsewhere, particularly in Java, *e.g.* in Mt. Guntur (Van Der Pijl, 1938), Mt. Ceremai, (Lam, 1925), Papandayan (Van Steenis, 1930, 1932, 1935; Van Steenis *et al.,* 1972, 2006; Docters Van Leeuwen, 1932) and Mt. Tangkuban Perahu (Wiljes-Hissink, 1953).

Another important and widespread species was *Carex verticillata* (Figure 6 & Annex 2), whose cover tends to increase and it takes over the dominance when *I. pangerangensis* or *Tripogon exiguus* was low in cover or absent in the community (R cover of –0.31 and 0.19, respectively, in Mandalawangi and –0.24 and –0.19, respectively, in Suryakencana) as indicated also in Figure 4. In Suryakencana, *Agrostis infirma* and *Gleichenia vulcanica* may become important also in places. The presence of such correlations reflects the pattern in vegetation and is usually related to habitat factors, yet to be investigated thoroughly.

The results of the present investigation show that the meadows in Mandalawangi and Suryakencana were similar, but they were relatively poor in species, confirming the earlier records. It has been assumed that poor soils and fires have maintained the perpetual existence of *A. javanica* in the meadows. Fire, while benefitting *A. javanica*, has also paved the way for the entry of aggressive exotic grass species, which were previously not present in the meadows, and are now threatening the purity of the native subalpine herbaceous vegetation on the tops of Mt. Gede-Pangrango. There was slight indication of invasion by leading tree species into the meadows that might lead to the formation of forests. These phenomena, however, need further detailed elucidatory ecological resesearch and long-term dynamic studies to monitor changes and to clarify the pattern of species distribution and dominance.

ACKNOWLEDGEMENT

We are grateful to UNESCO Jakarta Office for granting a financial support through the Indonesian National MAB Committee to undertake the study. Our gratitude also goes to the Mt. Gede-Pangrango National Park authority for providing facilities that enabled us to complete the field work. We thank Dr. H. Simbolon, and Dr. Scott Hoover, who went through the draft manuscript and provided constructive criticism and suggestions.

REFERENCES

ABDULHADI, R., SRIJANTO, A. & KARTAWINATA, K. 1998. Composition, structure, and changes in a montane rain forest at the Cibodas Biosphere Reserve, West Java, Indonesia. :601-612. *In* DALLMEIER, F. & COMISKEY, J.A. (Eds.). *Forest Biodiversity Research, Monitoring and Modeling. Conceptual Background and Old World Case Studies.* Man and the Biosphere Series, vol. 20. The Parthenon Publishing Group, New York.

BACKER, C.A. & BAKHUIZEN VAN DEN BRINK, JR., R.C. 1963–1968. *Flora of Java.* Wolters-Noordhoff, Groningen.

BALAI TNGGP. 2007. *Laporan Kegiatan Pemantauan Potensi dan Dinamika Bunga Edelweis Di Taman Nasional Gunung Gede Pangrango Cibodas-Cianjur.* Balai Taman Nasional Gunung Gede-Pangrango, Cibodas, Cianjur.

BLUME, C.L. 1825. Over de gesteldheid van het gebergte Gede. *Verh. Bat. Gen. K. W.* 10: 57 (*In* DOCTERS VAN LEEUWEN, W.M., 1933)

DOCTERS VAN LEEUWEN, W.M. 1930a. Beitrage zur kenntnis der Gipfelvegetation der in Miittel-Java gelegen Vulkane Sumbing und Sindoro. *Bull. Jard. Bot. Btzg.* III, 11: 28–56.

DOCTERS VAN LEEUWEN, W.M. 1930b. De kráter tegal Primula van den Goenoeng Ipis (Bij de Papandajan). *Trop. Nat.* 19: 121–123.

DOCTERS VAN LEEUWEN, W.M. 1933. Biology of plants and animals occuring in the higher parts of Mount Pangrango-Gedeh in West-Java. *Verh. Kon. Ak. Wet. A'dam. (Ned.)* (Sec. 2) 31: 1–288.

FAO, 1978. *Proposed Gn. Gede-Pangrango National Park, Management Plan, 1979-1983. Field Report of UNDP/ FAO. Nature Conservation and Wildlife Management Project*, INS/73/013. Food and Agriculture Organization of the United Nations, Bogor.

HASSKARL, J.K. 1840. Uitbarsting van den berg Gedeh, geduurende de maanden November en December 1840. *Tijdschr. Ned. Ind.* 4: 241 (*In* DOCTERS VAN LEEUWEN, W.M., 1933)

HELMI, N., KARTAWINATA, K. & SAMSOEDIN, I. (In preparation). Struktur dan komposisi hutan pamah di Bodogol, Taman Nasional Gunung Gede-Pangrango (Cagar Biosfer Cibodas), Jawa Barat (*Structure and species composition of a lowland forest at Bodogol, Mount Gede-Pangrango National Park (Cibodas Biosphere Reserve), West Java*).

HOPE, G.S. 1976. Vegetation. :112–172. *In* HOPE, G.S., PETERSON, J.A., ALLISON, I. & RADOK, U. (Eds.). *The equatorial glaciers of New Guinea.* Balkema, Rotterdam.

JOHNS, R.J., SHEA, G.A. & PURADYATMIKA, P. 2007. Subalpine and Alpine vegetation of Papua. :1024-1053. *In* MARSHALL, A.J. & BEEHLER B.M. (Eds). *The Ecology of Papua part two.* Periplus, Hongkong.

JUNGHUHN, F.W. 1845. *Topographische und naturwissenschaftliche reisen durch Java* (*In* VAN STEENIS *et al.* , 1972, 2006)

KOORDERS, S.H. 1918-1923. *Flora von Tjibodas,* 3 vols. Batavia

KORTHALS, P.W.1848. Warnemingen aangaarde den berg Gede op Java. *Ned. Kruidk. Archief* 1: 1848: 117 (*In* DOCTERS VAN LEEUWEN, W.M. 1933).

KRAMER, F. 1926. Onderzoek naar de natuurlijke verjonging in den uitkap in Preanger gebergtebosch. *Med. Proefst. Bos.* 14: 1–182

KRAMER, F. 1933. De natuurlijke verjongingin het Goenoeng Gedeh complex. *Tectona* 26: 156–185.

LAM, H.J. 1925. Een bestijging van den G. Tjareme. *Trop. Nat.* 14: 2–10.

LMG (LEMBAGA METEOROLOGI DAN GEOFISIKA), 1969. *Tjurah hudjan rata2 di Djawa dan Madura (Mean rainfall in Java and Madura), Periode 1931–1960.* Meteorological Note No. 8 Part 1. Lembaga Meteorologi dan Geofisika, Djakarta.

MEIJER, W. 1959. Plant sociological analysis of montane rain forest near Tjibodas, West Java. *Act. Bot. Neerl.* 8: 277–291.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1972. *Aims and methods of vegetation ecology.* John Wiley & Sons, New York.

REINWARDT, C. G. C. C. 1823. Over de hoogte en verdere natuurlijke gesteldheid eenige bergen in de Preanger Egentschappen. *Verh. Bat. Gen.* 9: 3. (*In* DOCTERS VAN LEEUWEN, W.M. 1933)

RUSTIAMI, H. 2004. Cagar Biosfer Cibodas. :11–34. *In* H. SOEDJITO (Ed.). *Panduan cagar biosfer di Indonesia.* Panitia Nasional MAB Indonesia, Lembaga Ilmu Pengetahuan Indonesia, Jakarta.

SCHMIDT, F.H. & FERGUSON, J.H. 1951. *Rainfall types based on wet and dry period ratios for Indonesia with Western New Guinea.* Verhandelingen Djawatan Meteorologi dan Geofisika, Djakarta 42.

SEIFRIZ, W. 1923. The altitudinal distribution of plants on Mt. Gedeh, West Java. *Bull. Tor. Bot. Cl.* 50: 283–306.

SRIJANTO, A. 1987. *Pengaruh rumpang terhadap permudaan alam dan struktur tegakan di hutan hujan tropika pegunungan.* M.Sc. Thesis, Fakultas Pasca Sarjana, IPB, Bogor.

SUMADIJAYA, A. & VELDKAMP, J. F. 2009. *Vulpia* (*Gramineae*) in Malesia. *Reinwardtia* 12(5): 343–345.

SUNARNO, B & RUGAYAH, 1992. *Flora Taman Nasional Gede Pangrango.* Herbarium Bogoriense, Puslitbang Biologi – LIPI, Bogor.

TEYSMANN, J.E. 1842. Kritische aantekeningen op de bijdragen van Doctor JUNGHUHN, tot de geschiedenis der vulkaanen in den Ned. Archipel. *Tijdschr. Ned. Ind.* 5: 487 (in DOCTERS VAN LEEUWEN, W.M.,1933).

UNESCO, MAB Indonesia & LBN. 1975. *Regional Postgraduate Training Course on Methods in Tropical Vegetation Analysis, Bogor, Indonesia, 1–30 September 1975.* UNESCO Regional Office for Science and Technology for Southeast Asia, Indonesian National Committee for MAB Programme and Lembaga Biologi Nasional-LIPI, Bogor.

VAN DER PIJL, I. 1938. The re-establishment of vegetation on Mt. Goentoer (Java). *Ann. Jard. Bot. Btzg.* 48: 129–152.

VAN STEENIS, C.G.G.J. 1930. Eeenige belangrijke plantengeographische vondsten op den Papandayan. *Trop. Nat.* 19: 73–91.

VAN STEENIS, C.G.G.J.. 1932. Eeenige belangrijke plantengeographische vondsten op den Papandayan. II. *Trop. Nat.* 21: 101–108.

VAN.STEENIS, C.G.G.J. 1935. Eeenige biologische waarnemingen op den Papandajan. *Trop. Nat.* 24: 141–147.

VAN STEENIS, C.G.G.J., HAMZAH, A. & TOHA, M. 1972. *The Mountain Flora of Java.* E.J. Brill, Leiden.

VAN STEENIS, C.G.G.J., HAMZAH, A. & TOHA, M. 2006. *Flora Pegunungan Jawa.* Pusat Penelitian Biologi – LIPI, Bogor.

VAN STEENIS, C.G.G.J. & VAN STEENIS-KRUSEMAN, M,J. 1953. A brief sketch of the Tjibodas Mountain Garden. *Fl. Mal. Bull.* 10: 312–351

WENT, F. W. 1940. Soziologie der Epiphyrten eines tropischen Urwaldes. *Ann. Jard. Bot.*

Btzg. 50: 1–17.

WILJES-HISSINK, E.A. 1953. Twee excursies naar de Tangkuban Prahu. *Trop. Nat.* 32:115–119.

YAMADA, 1. 1975. Forest ecological studies of the montane forest of Mt. Pangrango, West Java. I. Stratification and floristic composition of the montane rain forest near Cibodas. *The Southeast Asian Studies* 13: 402–426.

YAMADA, I. 1976a. Forest ecological studies of the montane forest of Mt. Pangrango, West Java. II. Stratification and floristic composition of the forest vegetation of the higher part of Mt. Pangrango. *The Southeast Asian Studies* 13: 513–534.

YAMADA, L. 1976b. Forest ecological studies of the montane forest of Mt. Pangrango, West Java. III. Litter fall of the tropical montane forest near Cibodas. *The Southeast Asian Studies* 14: 194–229.

YAMADA, I. 1977. Forest ecological studies of the montane forest of Mt. Pangrango, West Java. IV. Floristic along the altitude. *The Southeast Asian Studies* 15: 226–254.

Annex 1. List of species of saplings, shrubs and woody herbs with their values on Relative Dominance (RDo), Relative Density (RD), Relative Frequency (RF) and Importance Value (IV) at the Mandalawangi, Suryakencana and the Crater Side at the tops of Mt. Gede-Pangrango, Cibodas Biosphere Reserve.

NO.	SPECIES	FAMILY	MANDALAWANGI				SURYAKENCANA				CRATER SIDE			
			RDo	RD	RF	IV	RDo	RD	RF	IV	RDo	RD	RF	IV
1	*Anaphalis javanica*	*Asteraceae*	69.0	70.0	48.0	187.0	82.8	66.8	44.8	194.3	1.0	1.0	6.6	8.5
2	*Vaccinium varingiaefolium*	*Ericaceae*	6.3	2.5	8.1	16.8	4.7	7.6	13.3	25.6	72.0	78.9	32.8	183.7
3	*Leptospermum flavescens*	*Myrtaceae*	5.0	11.1	10.4	26.5	1.8	3.6	8.1	13.5	1.0	0.2	1.6	2.9
4	*Gaultheria punctata*	*Ericaceae*	0.8	1.1	4.1	6.0	7.6	15.9	19.5	43.0	8.6	5.0	16.4	30.0
5	*Symplocos cochinchinensis*	*Symplocaceae*	3.4	0.8	5.2	9.4	0.4	1.1	2.6	4.1	0.9	0.2	1.6	2.8
6	*Rubus lineatus*	*Rosaceae*	0.4	2.1	2.9	5.4	0.1	0.3	0.7	1.1	0.7	0.2	1.6	2.6
7	*Eurya glabra*	*Theaceae*	2.9	0.3	1.7	4.9	0.2	0.2	0.7	1.1	0.6	1.0	4.9	6.5
8	*Lonicera javanica*	*Caprifoliaaceae*	2.1	1.4	4.6	8.1	0.8	1.8	3.3	5.9				
9	*Photinia integrifolia*	*Rosaceae*	0.8	1.3	5.2	7.4	1.1	1.8	3.8	6.6				
10	*Rapanea avenis*	*Myrsinaceae*	1.7	8.0	3.5	13.1	0.1	0.3	0.5	0.9				
11	*Vaccinium laurifolium*	*Ericaceae*	1.3	0.7	2.9	4.9	0.3	0.3	1.0	1.6				
12	*Rubus* sp.	*Rosaceae*					0.0	0.1	0.2	0.3				
13	*Dicrochepala chrysantemifolia*	*Asteraceae*					0.1	0.1	1.0	1.1				
14	*Albizia lophanta*	*Fabaceae*					0.0	0.1	0.5	0.7	3.1	1.4	6.6	11.3
15	*Rhododenron retusum*	*Ericaceae*									11.7	11.3	24.6	47.7
16	*Scheflera lucescens*	*Araliaceae*									0.6	0.7	3.3	4.6
17	*Malus domestica*	*Rosaceae*	5.4	0.1	0.6	6.1								
18	*Hypericum leschenaultii*	*Ericaceae*	0.8	0.8	2.9	4.6								
Total			100	100	100	300	100	100	100	300	100	100	100	300

Annex 2. List of species of seedlings and herbs with percentages of their Relative Dominance (RDo), Relative Density (RD), Relative Frequency (RF) and Importance Value (IV) at Mandalawangi, Suryakencana and the Crater Side at the top of Mt. Gede- Pangrango

No	SPECIES	FAMILY	MANDALAWANGI				SURYAKENCANA				CRATER SIDE			
			RDo	RD	RF	IV	RDo	RD	RF	IV	RDo	RD	RF	IV
1	*Gaultheria nummulariodes.*	*Ericaceae*	0.4	0.5	16.53	7.43	0.79	0.63	5.88	7.30	0.2	0.3	7.69	8.2
2	*Hypericum leschenaultii*	*Hypericaceac*	0.1	0.2	0.83	1.13								
3	*Laurembergia coccinea*	*Haloragaceae*	1.7	0.1	4.96	6.76								
4	*Rubus lineatus*	*Rosaceae*	0.4	0.2	0.83	1.43								
5	*Rapanea avenis*	*Myrsinaceae*	0.2	0.4	0.83	1.43								
6	*Tripogon exiguus*	*Poaceae*	38.5	28	18.18	84.68	54.7	34.69	12.25	101.60				
7	*Isachne pangerangensis*	*Poaceae*	30.3	48	19.01	97.31	7.05	30.13	12.25	49.43				
8	*Carex verticillata*	*Cyperaceae*	18.7	19	18.18	5.88	18.3	24.51	12.25	55.08				
9	*Anaphalis javanica*	*Asteraceae*	2.6	1.9	11.6	6.07	1.53	0.58	8.09	10.20				
10	*Potentilla indica*	*Rosaceae*	0.2	0.5	0.83	1.53	1.17	0.2	3.68	5.05				
11	*Lycopodium* sp.	*Lycopodiaceae*	7	1.2	8.26	16.46	0.93	1.74	9.80	12.47				
12	*Thelymitra javanica*	*Orchidaceae*					0.47	0.02	0.25	0.74				
13	*Gleichenia vulcanica*	*Gleicheniaceae*					2.4	2.12	7.35	11.87				
14	*Imperata cylindrica*	*Poaceae*					0.74	0.11	2.94	3.79				
15	*Leptospermum flavescens*	*Myrtaceae*					0.35	0.04	0.49	0.88				
16	*Agrostis infirma*	*Poaceae*					5.92	4.08	12.25	22.25				
17	*Photinia integrifolia*	*Rosaceae*					0.47	0.01	0.25	0.73				
18	*Vaccinium varingiaefolium*	*Ericaceae*					2.56	0.13	3.43	6.12	17.4	9	23.08	49.5
19	*Gaultheria punctata*	*Ericaceae*					2.6	1	8.58	12.18	1.1	0.3	7.69	9.1
20	*Rhododendron retusum*	*Ericaceae*					0.04	0.01	0.25	0.30	2.5	0.8	23.08	26.4
21	*Selliguiea feei*	*Polypodiaceae*									78.7	89.7	8.46	206.9
		TOTAL	100	100	100	300	100	100	100	300	100	100	100	300

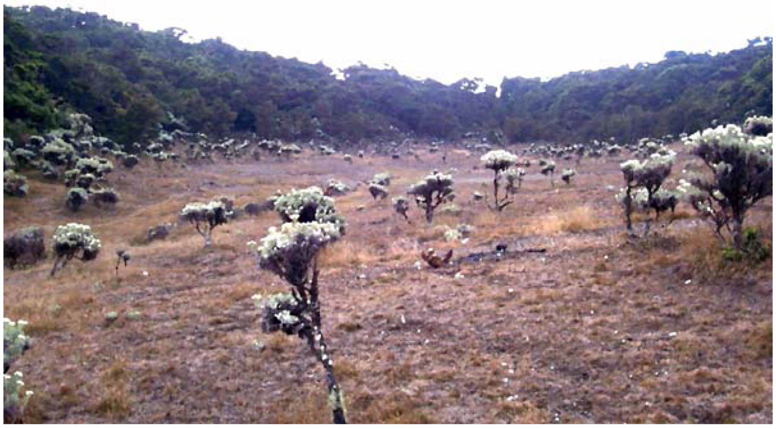


Figure 7. The subalpine *Anaphalis javanica-Isachne pangerangensis* community type in Alun-alun Mandalawangi at the Mt. Pangrango summit, surounded by subalpine *Leptospermum flavescens* forest.

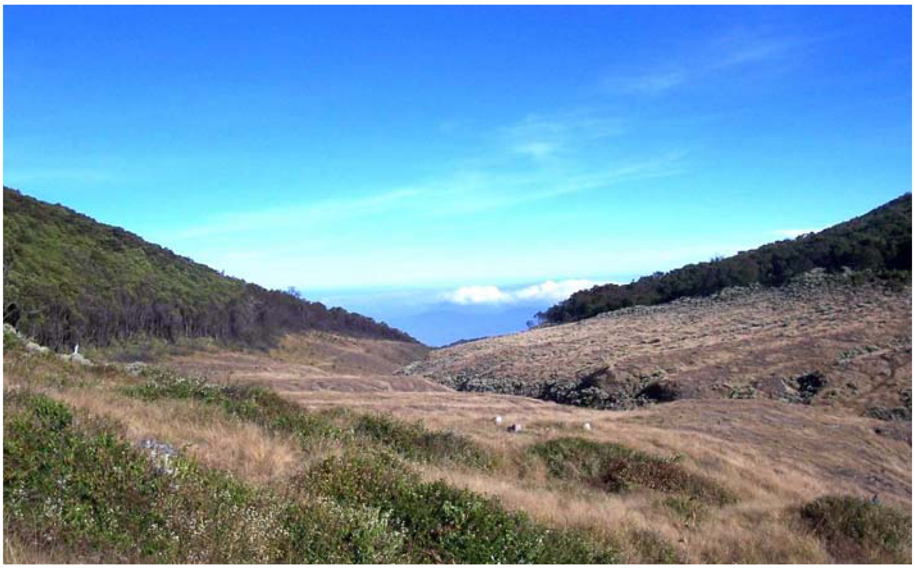


Figure 8. An overview of the subalpine *Anaphalis javanica-Tripogon exiguous* community type at Alun-alun Suryakencana in the Mt. Gedeh summit, complex, surrounded by subalpine forest dominated by *Vaccinium varingiaefolium* and *Leptospermum flavescens* or in places by *Albizia lophanta*

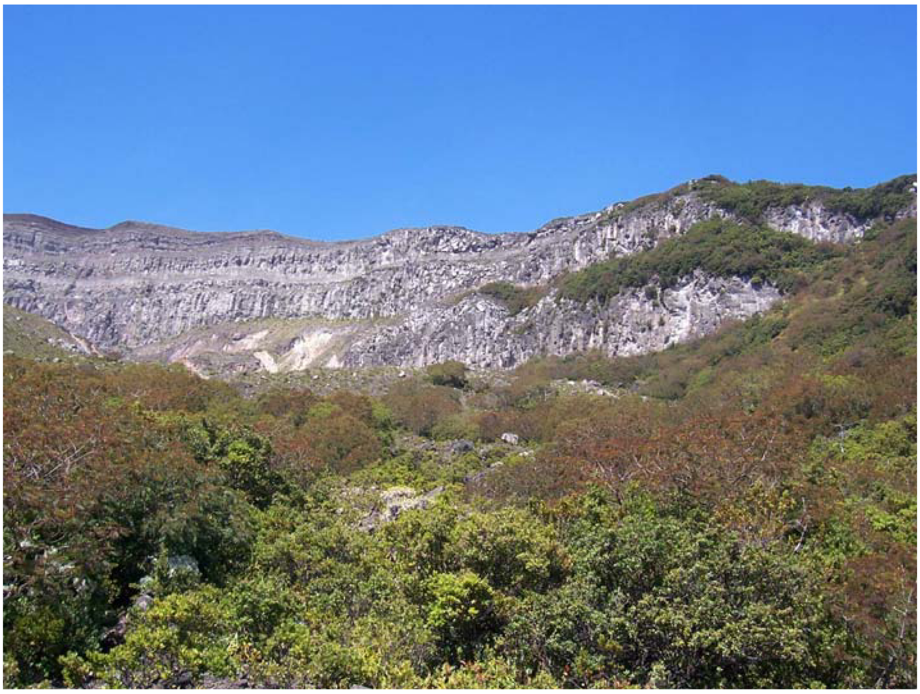


Figure 9. The subalpine *Vaccinium varingiaefolium-Seliguea feei* community type, surrounded by subalpine *Albizia lophanta* forest at the Crater Side in the Mt. Gede summit complex.